

# Neurotechnology+0001

Neurotechnology

*Slap Fingerprint Segmentation Evaluation III*

*Last Updated: 04 September 2020*

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# 1 Participation Information

## 1.1 Names and Dates

- **Organization Name:** Neurotechnology
- **SlapSeg III Identifier:** Neurotechnology+0001
- **Provided Marketing Name:** “MegaMatcher”
- **Application Date:** 27 February 2019
- **First Submission Date:** 29 April 2019 (as version 0000)
- **Validation Date:** 08 May 2019
- **Completion Date:** 08 May 2019

## 1.2 Libraries

Filename	MD5 Checksum	Size
Fingers.ndf	2c64094f25b2e21c692d9ee1c38da3cb	1.5 Mb
libinference_engine.so	b5f030ca684a4ff4e75bc81b526b5dd2	4.1 Mb
libiomp5.so	2729cb28f53ff764c280a30474e10bea	2 Mb
libMKLDNNPlugin.so	26f184987694185b14d3cdd15005d92a	13.9 Mb
libmkl_tiny_omp.so	2970e5c3f5154ad7c13b3136736143e0	26.6 Mb
libslapsegiii_Neurotechnology_0001.so	f586c7a338c6d120e7129f914f25d0a7	10.1 Mb

## 2 Tenprint Cards (“TwoInch” Data)

### 2.1 Segmentation Timing

All algorithms are run over a small fixed corpus of TwoInch images to estimate the total runtime of the evaluation. To be evaluated under SlapSeg III, algorithms **must** segment the timing corpus, on average, in under 1 500 milliseconds. This maximum reference time is documented in the SlapSeg III test plan, and is subject to change.

Box plots of segmentation times are separated by slap orientation and capture technology in Figure 1. Tabular representations are enumerated in Table 1. Results are reported in milliseconds.

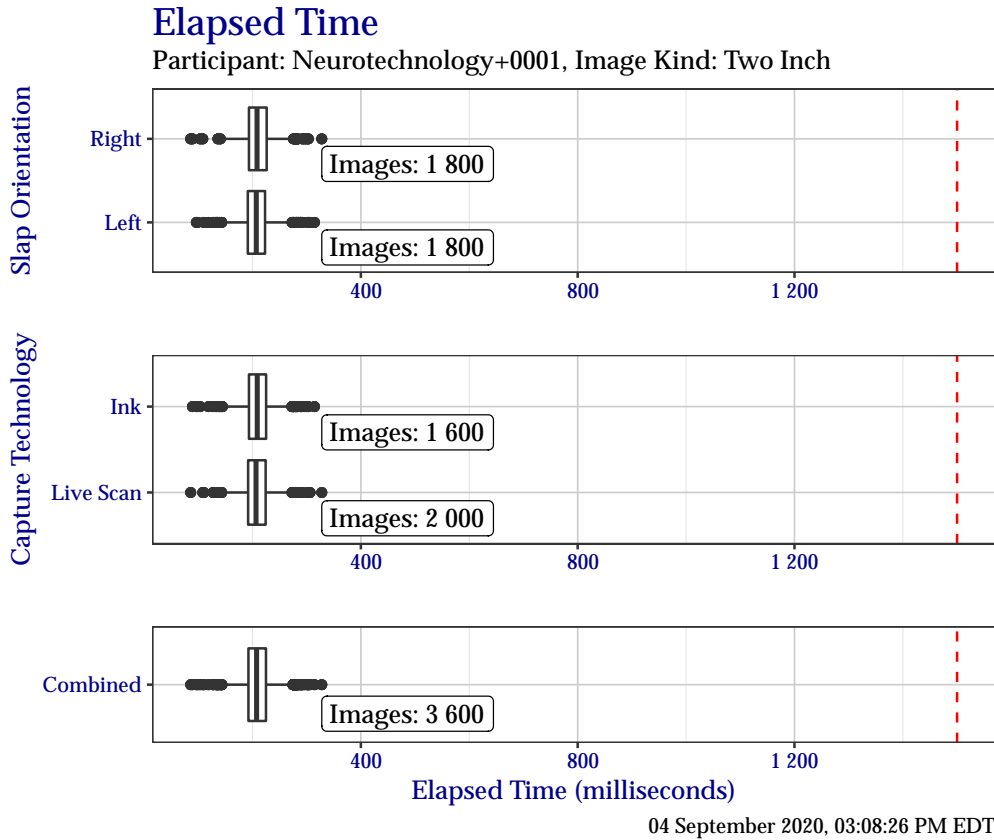


Figure 1: Box plots of elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

Table 1: Elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

	Right	Left	Live Scan	Ink	Combined
Minimum	86	97	86	89	86
25%	194	191	192	194	193
Median	208	207	207	209	208
75%	226	223	224	225	225
Maximum	328	314	328	314	328

## 2.2 Segmentation Centers and Dimensions

### 2.2.1 Segmentation Centers

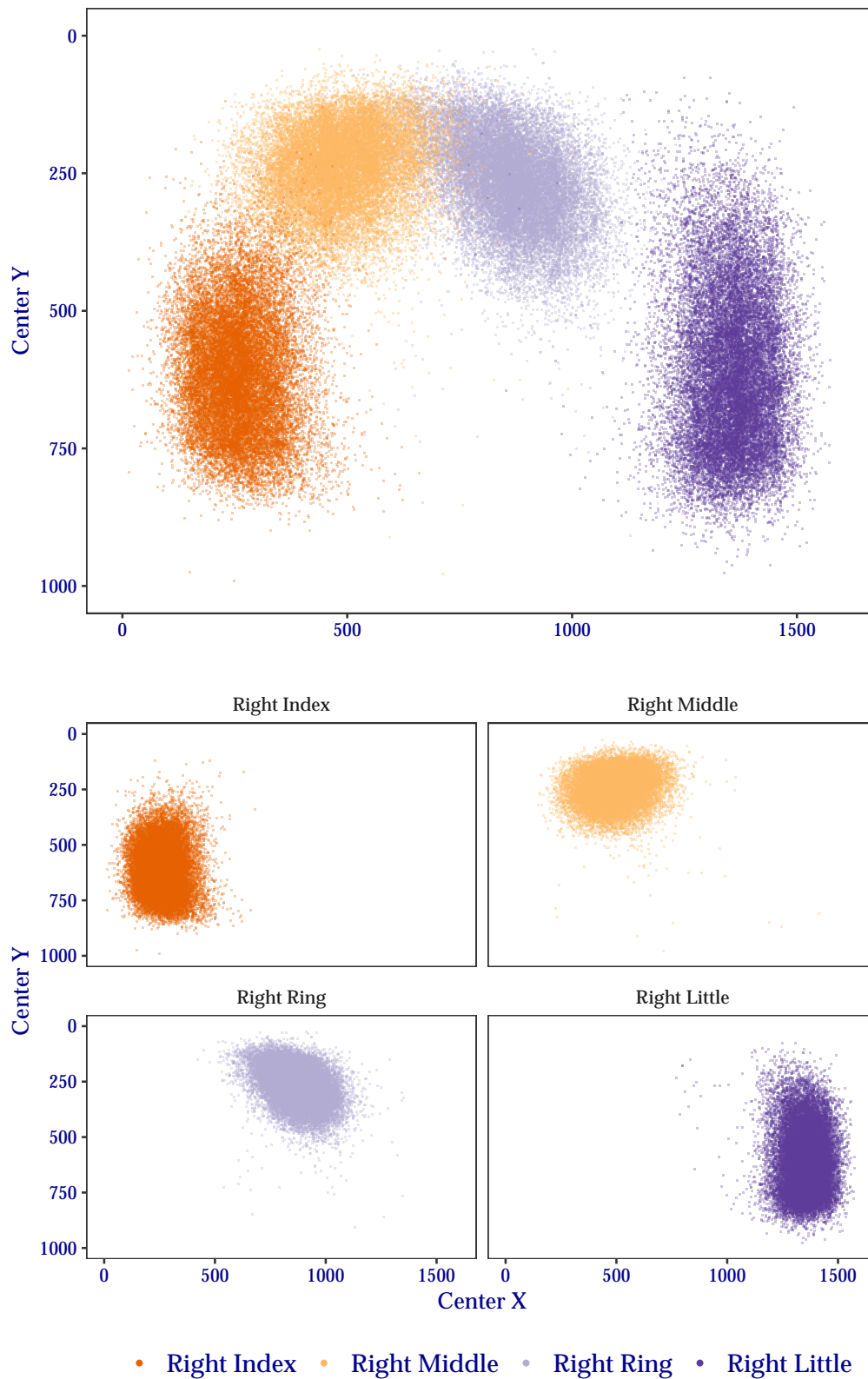
The plots in this section show the distribution of segmentation position centers  $(x, y)$  for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

Plots of segmentation centers for the right hand TwoInch data are shown in Figure 2 and plots of segmentation centers for the left hand are shown in Figure 3. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Centers have been normalized to 500 pixels per inch.

Points in each plot are plotted with a semi-transparent opacity. This results in points of particular color appearing “darker” to indicate a higher frequency of the observed value, while “lighter” points indicate a lower observed frequency.

## Segmentation Position Centers

Participant: Neurotechnology+0001, FRGPs: 2, 3, 4, 5, Image Kind: Two Inch

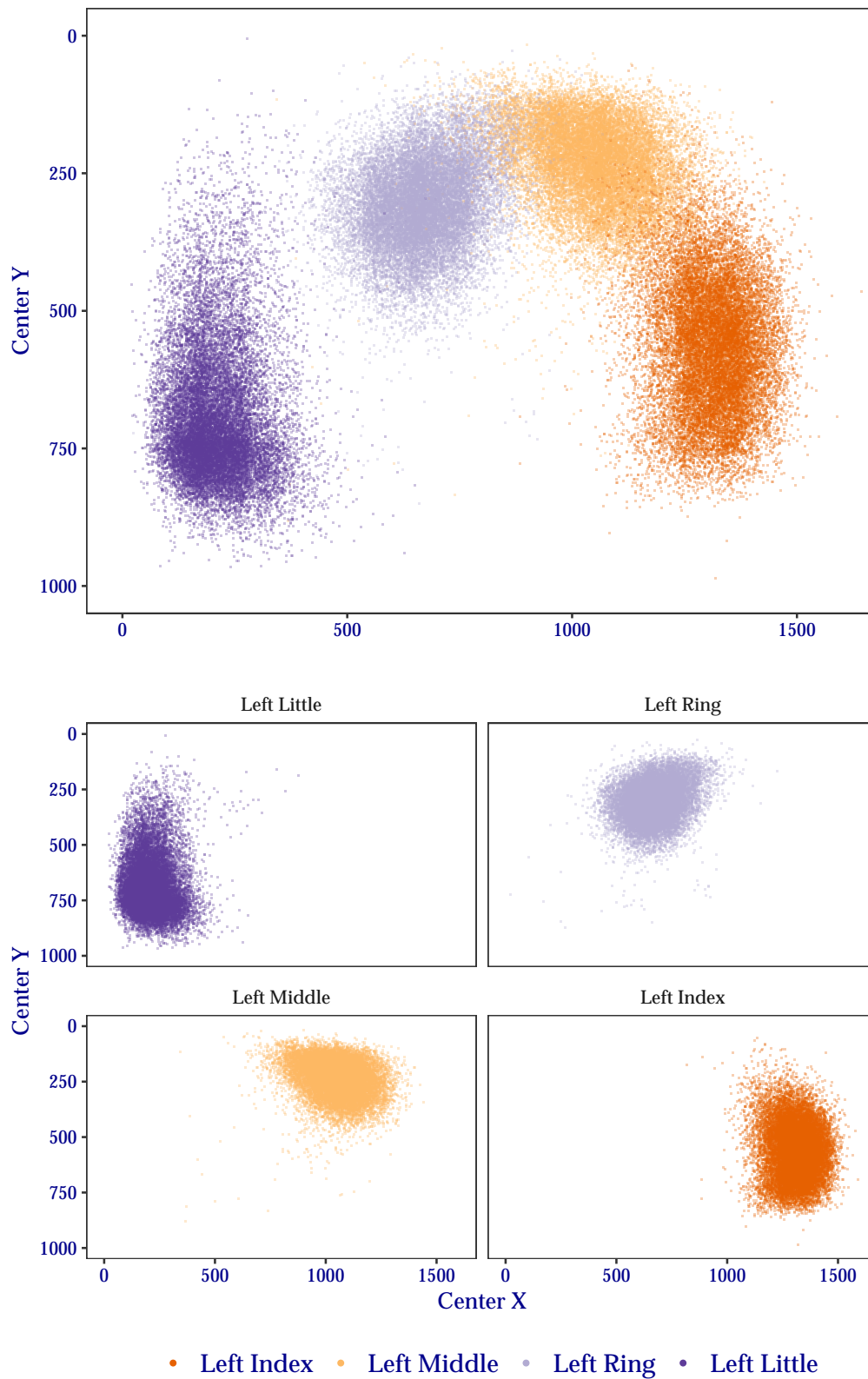


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Figure 2: Segmentation centers for right hand TwoInch data.

## Segmentation Position Centers

Participant: Neurotechnology+0001, FRGPs: 7, 8, 9, 10, Image Kind: Two Inch



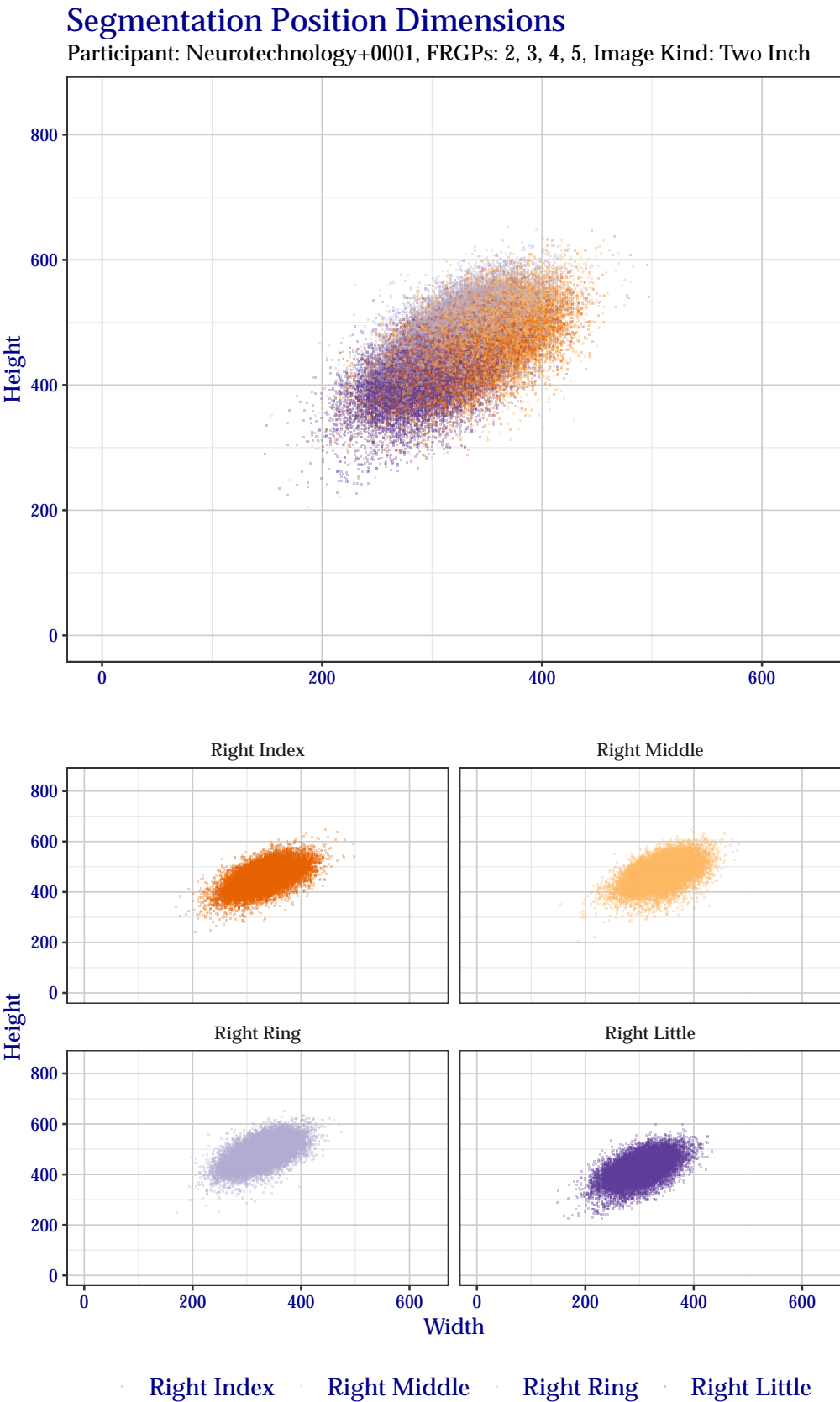
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Figure 3: Segmentation centers for left hand TwoInch data.

### 2.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

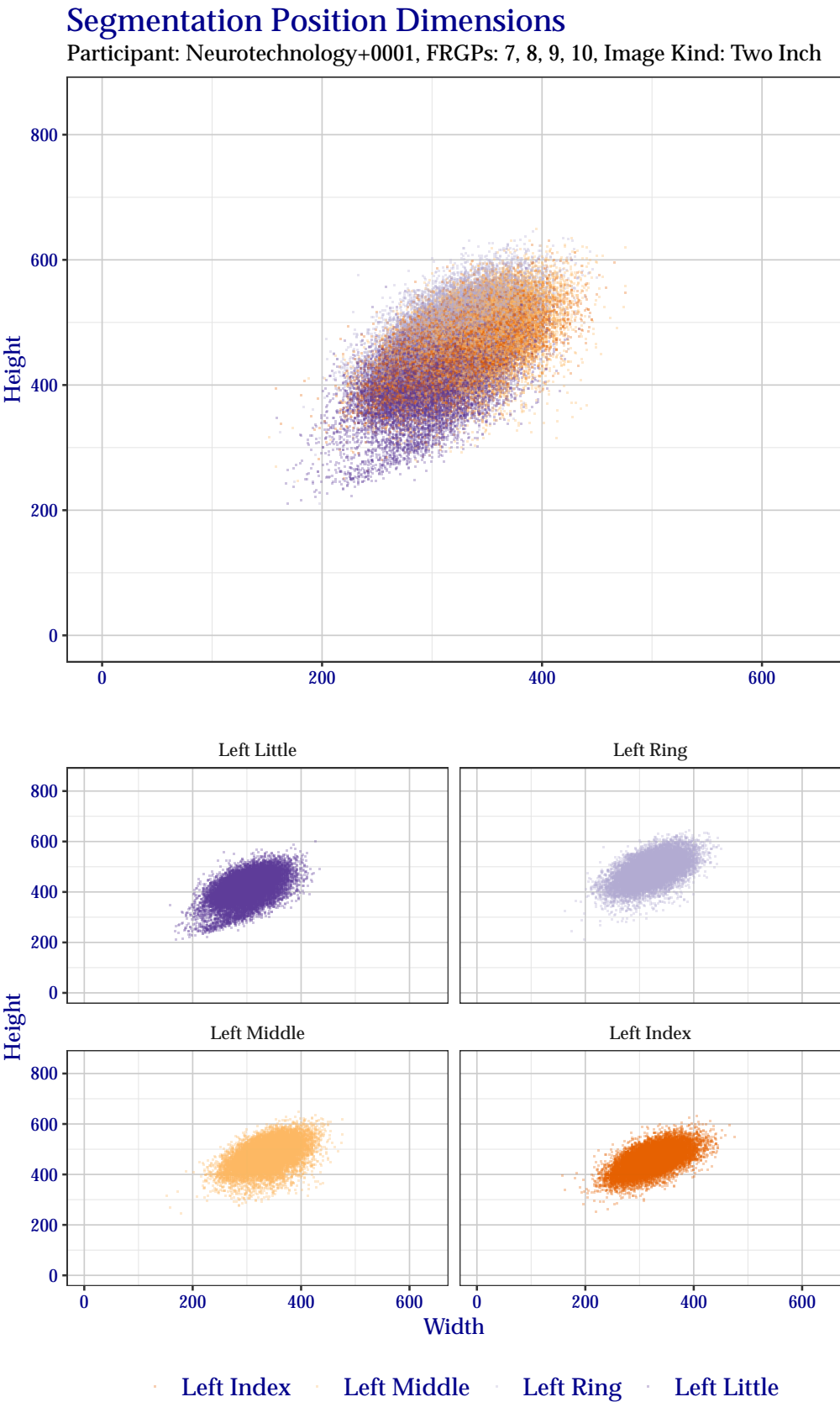
Plots of segmentation position dimensions for the right hand TwoInch data are shown in Figure 4 and the left hand in Figure 5. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Dimensions have been normalized to 500 pixels per inch.



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Figure 4: Segmentation position dimensions for right hand TwoInch data.





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Figure 5: Segmentation position dimensions for left hand TwoInch data.

## 2.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of TwoInch data. Values in each table are the percentage that the variable in the left-most column was correctly segmented.

Each table has three columns of percentages. The *Standard Scoring* column shows the percentage of correctly-segmented positions based on the scoring metrics defined in the SlapSeg III scoring document. The *Ignoring Bottom Y* column shows how the percentage would change if the threshold for the *bottom Y* coordinate of the segmentation position was ignored. Similarly, the *Ignoring Bottom X and Y* columns shows how the percentage would change if only the top, left, and right sides of the segmentation position were considered. These two supplemental columns are included because it has traditionally been difficult to determine the exact location of the distal interphalangeal joint.

Table 2 shows how successful Neurotechnology+0001 segmented fingers for each subject in the test corpus. Table 3 shows success for specific finger positions over the entire test corpus. Similarly, Table 4 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers on each slap image. Table 5 shows success for combinations of all fingers, Table 6 for just the index and middle fingers, and Table 7 for all except the little finger.

Table 2: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	99.8	99.8	99.9
2	99.6	99.7	99.7
3	99.3	99.3	99.4
4	98.5	98.6	98.7
5	95.0	95.1	95.3
6	94.0	94.2	94.4
7	90.3	91.0	91.4
8	76.0	78.7	79.2

Table 3: For all subjects, percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Index	97.8	98.8	99.0
Middle	93.6	94.0	94.1
Ring	97.3	97.7	97.8
Little	98.2	98.7	98.9
<b>Left</b>			
Index	97.8	98.4	98.4
Middle	90.2	90.7	90.7
Ring	97.3	97.9	98.0
Little	96.7	97.0	97.5

Table 4: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Index</b>			
Either	99.3	99.4	99.4
Both	92.2	93.5	93.7
<b>Middle</b>			
Either	97.6	97.7	97.8
Both	82.4	83.1	83.2
<b>Ring</b>			
Either	99.3	99.4	99.4
Both	91.3	92.2	92.5
<b>Little</b>			
Either	99.2	99.3	99.4
Both	91.3	92.0	92.6

Table 5: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Any	99.7	99.7	99.8
At Least Two	99.4	99.5	99.6
At Least Three	98.4	98.6	98.8
All Four	89.3	91.4	91.7
<b>Left</b>			
Any	99.5	99.6	99.7
At Least Two	99.0	99.0	99.2
At Least Three	97.4	97.6	97.8
All Four	86.1	87.7	88.1

Table 6: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Either Index or Middle	99.3	99.4	99.5
Both Index and Middle	92.0	93.4	93.6
<b>Left</b>			
Either Index or Middle	98.9	99.0	99.1
Both Index and Middle	89.1	90.0	90.1

Table 7: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Any	99.6	99.6	99.7
At Least Two	98.7	98.9	99.0
All Three	90.3	92.0	92.3
<b>Left</b>			
Any	99.4	99.4	99.5
At Least Two	98.1	98.3	98.4
All Three	87.9	89.2	89.3

## 2.4 Handling Troublesome Images

### 2.4.1 Capture Failures

Segmentation algorithms may refuse to process an image. This may happen for a technical reason (e.g., the algorithm cannot parse the image data), or for a practical reason (e.g., the hand in the image is placed incorrectly). These failure scenarios are the result of capturing improper image data. In these types of scenarios, it is important to examine the cause of the failure. With many live scan capture setups, segmentation is performed immediately after capture. If an algorithm can detect that it won't be able to segment an image due to a technical or practical issue, it can alert the operator to perform a recapture before the subject leaves.

The SlapSeg III API encourages algorithms to identify these failure reasons by specifying pre-defined *deficiencies* in the image. Algorithms should attempt segmentation even if an image deficiency is encountered if at all possible. Note that SlapSeg III *guarantees* well-formed image data, so failures to parse are **not** an indicator of the data provided.

Reasons for capture-type failures reported by Neurotechnology+0001 are enumerated in Table 8. Note that for TwoInch data, images are expected to be rotated, so a capture failure of *Rotation Detected* is unacceptable.

Table 8: Count of self-reported capture-type failure reasoning.

Failure Reason	Images
Request Recapture (No Attempt)	22

In situations where the algorithm feels that the presented image should be recaptured (Table 8), one or more image deficiencies must be identified. These deficiencies are enumerated in Table 9. At this point, NIST does not have a groundtruth of image deficiencies, but plans to update this table with the accuracy of deficiency observations in the future.

Table 9: Count of image deficiencies reported when requesting a recapture.

Deficiency	Count
Incomplete	21
Hand Geometry	1

#### 2.4.1.1 Recovery

When encountering a segmentation failure, SlapSeg III algorithms are encouraged to provide a *best-effort* segmentation when possible. In some cases, that best-effort may be correct, which reduces the amount of images that need to be manually adjudicated by an operator.

Neurotechnology+0001 did not attempt any recovery segmentations.

### 2.4.2 Segmentation Failures

Even if an algorithm accepts an image for processing, it can still fail to process one or more fingers from the image, regardless of if the algorithm requested a recapture and provided best-effort segmentation.

The SlapSeg III API allows algorithms to communicate reasons for failure to process these fingers. In some cases, the distal phalanx in question might not be present in the image due to amputation or being placed outside the platen's capture area. It is imperative that the segmentation algorithm correctly report this as failing to segment the correct friction ridge generalized position without disrupting the sequence of

valid positions present in the image. This can help prompt an operator to recapture or record additional information about the subject.

In SlapSeg III, a number of images are missing fingers or otherwise have fingers that will not be able to be segmented. Reasons for segmentation failures reported by Neurotechnology+0001 are enumerated in Table 10.

Table 10: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	615
Finger Found, but Can't Segment	0
Vendor Defined	0

### 2.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 11 shows how successful Neurotechnology+0001 was in correctly determining if a finger was missing. The *Missed* row shows when a segmentation position was returned for a missing finger. All possible failure reasons are enumerated, but are not considered *Correctly Identified* because the algorithm specified failure for a reason other than the finger not being found.

Table 11: Performance of Neurotechnology+0001 at detecting fingers missing from an image.

Result	Percentage
Missed	9.4
Correctly Identified	40.6
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	50.0

### 2.4.4 Sequence Error

Sequence error occurs when a fingerprint is segmented from an image but assigned an incorrect finger position (e.g., segmenting a right middle finger but labeling it a right index finger). Table 12 shows cases in which a segmentation position was returned that matched a ground truth segmentation position for a different finger in the same image.

Table 12: Percentage of images in the dataset where one or more segmentation positions correctly matched an incorrect finger position within the same image, indicating sequence error.

Hand	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Left	0.26	0.26	0.28
Right	0.18	0.18	0.18
Combined	0.22	0.22	0.23

## 2.5 Determining Orientation

An *optional* portion of the SlapSeg III API asked participants to determine the hand orientation of an image. Participants were provided the kind (e.g., Tenprint card) and capture technology (e.g., ink), and needed to determine whether the image was of the left or right hand.

**Overall Two Inch accuracy:** 99.6%

Table 13: Percentage of accuracy when determining hand orientation of a two inch image. The first column indicates the true hand orientation. Subsequent columns indicate the percentage of the time in which the indicated hand orientation was hypothesized.

	Left	Right	Skip
Left	<b>99.6</b>	0.3	0.1
Right	0.3	<b>99.7</b>	0

## A Tenprint Cards (“TwoInch” Data)

### A.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of TwoInch data from Section 2.3, but with an added bootstrap confidence interval. For each observation, a bootstrap routine with 1 000 replicates was run, and a 95 % confidence interval extracted. The lower and upper confidence from that confidence interval are printed in each column within square brackets.

In Table 14, results are shown of how successful Neurotechnology+0001 segmented fingers for each subject in the test corpus. Table 15 shows success for specific finger positions over the entire test corpus. Similarly, Table 16 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers in each slap image. Table 17 shows success for combinations of all fingers, Table 19 for the all except the little finger, and Table 18 for just the index and middle fingers.

Table 14: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	99.8 [99.8, 99.9]	99.8 [99.7, 99.9]	99.9 [99.8, 99.9]
2	99.6 [99.5, 99.7]	99.7 [99.5, 99.7]	99.7 [99.6, 99.8]
3	99.3 [99.2, 99.5]	99.3 [99.2, 99.5]	99.4 [99.3, 99.5]
4	98.5 [98.3, 98.7]	98.6 [98.5, 98.8]	98.7 [98.5, 98.9]
5	95.0 [94.7, 95.4]	95.1 [94.7, 95.5]	95.3 [94.9, 95.7]
6	94.0 [93.6, 94.4]	94.2 [93.8, 94.6]	94.4 [94.0, 94.8]
7	90.3 [89.8, 90.8]	91.0 [90.5, 91.5]	91.4 [90.9, 91.9]
8	76.0 [75.3, 76.7]	78.7 [78.0, 79.4]	79.2 [78.5, 79.9]

Table 15: For all subjects, Percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Index	97.8 [97.6, 98.0]	98.8 [98.6, 98.9]	99.0 [98.8, 99.1]
Middle	93.6 [93.2, 93.9]	94.0 [93.7, 94.3]	94.1 [93.8, 94.5]
Ring	97.3 [97.0, 97.5]	97.7 [97.5, 97.9]	97.8 [97.6, 98.0]
Little	98.2 [98.1, 98.4]	98.7 [98.6, 98.9]	98.9 [98.8, 99.0]
<b>Left</b>			
Index	97.8 [97.6, 98.0]	98.4 [98.2, 98.5]	98.4 [98.2, 98.6]
Middle	90.2 [89.8, 90.6]	90.7 [90.3, 91.1]	90.7 [90.3, 91.1]
Ring	97.3 [97.1, 97.5]	97.9 [97.7, 98.1]	98.0 [97.8, 98.2]
Little	96.7 [96.4, 96.9]	97.0 [96.8, 97.2]	97.5 [97.3, 97.8]



Table 16: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Index</b>			
Either	99.3 [99.2, 99.5]	99.4 [99.2, 99.5]	99.4 [99.3, 99.5]
Both	92.2 [91.7, 92.6]	93.5 [93.0, 93.9]	93.7 [93.3, 94.2]
<b>Middle</b>			
Either	97.6 [97.3, 97.9]	97.7 [97.5, 98.0]	97.8 [97.5, 98.0]
Both	82.4 [81.7, 83.0]	83.1 [82.5, 83.8]	83.2 [82.6, 83.9]
<b>Ring</b>			
Either	99.3 [99.1, 99.4]	99.4 [99.2, 99.5]	99.4 [99.3, 99.5]
Both	91.3 [90.9, 91.8]	92.2 [91.8, 92.7]	92.5 [92.0, 92.9]
<b>Little</b>			
Either	99.2 [99.1, 99.4]	99.3 [99.1, 99.4]	99.4 [99.2, 99.5]
Both	91.3 [90.8, 91.7]	92.0 [91.5, 92.4]	92.6 [92.2, 93.1]

Table 17: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Any	99.7 [99.6, 99.7]	99.7 [99.6, 99.7]	99.8 [99.7, 99.8]
At Least Two	99.4 [99.1, 99.3]	99.5 [99.2, 99.3]	99.6 [99.3, 99.4]
At Least Three	98.4 [97.8, 98.1]	98.6 [98.0, 98.3]	98.8 [98.2, 98.5]
All Four	89.3 [87.5, 88.1]	91.4 [89.4, 90.0]	91.7 [89.7, 90.3]
<b>Left</b>			
Any	99.5 [99.6, 99.7]	99.6 [99.6, 99.7]	99.7 [99.7, 99.8]
At Least Two	99.0 [99.1, 99.3]	99.0 [99.2, 99.3]	99.2 [99.3, 99.4]
At Least Three	97.4 [97.8, 98.1]	97.6 [98.0, 98.3]	97.8 [98.2, 98.5]
All Four	86.1 [87.5, 88.1]	87.7 [89.4, 90.0]	88.1 [89.7, 90.3]

Table 18: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Either Index or Middle	99.3 [99.0, 99.2]	99.4 [99.1, 99.3]	99.5 [99.2, 99.4]
Both Index and Middle	92.0 [90.4, 90.9]	93.4 [91.5, 92.1]	93.6 [91.7, 92.2]
<b>Left</b>			
Either Index or Middle	98.9 [99.0, 99.2]	99.0 [99.1, 99.3]	99.1 [99.2, 99.4]
Both Index and Middle	89.1 [90.4, 90.9]	90.0 [91.5, 92.1]	90.1 [91.7, 92.2]

Table 19: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
<b>Right</b>			
Any	99.6 [99.4, 99.6]	99.6 [99.4, 99.6]	99.7 [99.5, 99.7]
At Least Two	98.7 [98.3, 98.5]	98.9 [98.5, 98.7]	99.0 [98.6, 98.8]
All Three	90.3 [88.9, 89.5]	92.0 [90.4, 91.0]	92.3 [90.6, 91.2]
<b>Left</b>			
Any	99.4 [99.4, 99.6]	99.4 [99.4, 99.6]	99.5 [99.5, 99.7]
At Least Two	98.1 [98.3, 98.5]	98.3 [98.5, 98.7]	98.4 [98.6, 98.8]
All Three	87.9 [88.9, 89.5]	89.2 [90.4, 91.0]	89.3 [90.6, 91.2]

## A.2 Jaccard Index

Table 20: For each subject, the percentage that at least *Number of Fingers* fingers were segmented with a Jaccard index in the indicated range.

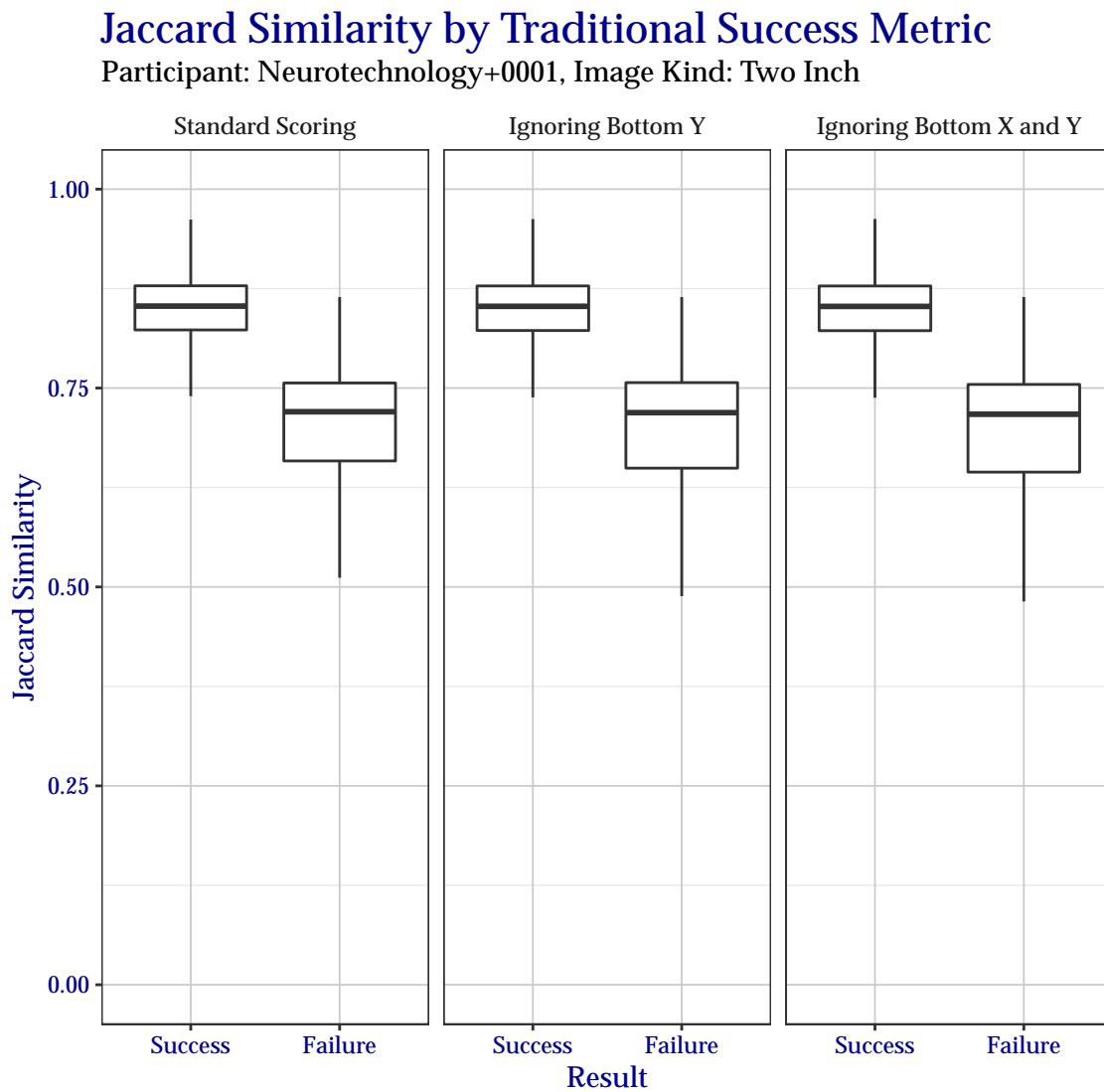
Number of Fingers	$\geq 0.5$	$\geq 0.6$	$\geq 0.7$	$\geq 0.8$	$\geq 0.9$	$\geq 0.95$	$\geq 0.98$
1	99.9	99.9	99.9	99.7	45.6	2.5	0.1
2	99.8	99.8	99.8	99.3	20.9	0.2	0.0
3	99.6	99.6	99.5	98.0	8.8	0.0	0.0
4	99.3	99.2	98.8	93.9	2.9	0.0	0.0
5	95.8	95.8	95.7	86.2	0.6	0	0
6	95.6	95.6	95.1	75.9	0.1	0	0
7	95.0	94.9	92.4	58.7	0.0	0	0
8	92.9	91.6	81.1	31.8	0	0	0

Table 21: For all subjects, percentage that a particular friction ridge generalized position was segmented with a Jaccard index in the indicated range.

Finger	0-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
<b>Right</b>						
Index	0.3	0.1	0.6	8.6	77.8	12.6
Middle	0.7	0.1	1.8	14.0	72.4	11.0
Ring	0.3	0.0	0.5	7.6	79.4	12.2
Little	0.3	0.1	0.8	7.7	70.5	20.6
<b>Left</b>						
Index	0.4	0.0	0.6	14.5	77.6	6.9
Middle	1.4	0.3	4.1	28.2	63.1	2.9
Ring	0.6	0.2	1.4	16.3	77.3	4.2
Little	0.8	0.5	3.0	24.0	66.6	5.1

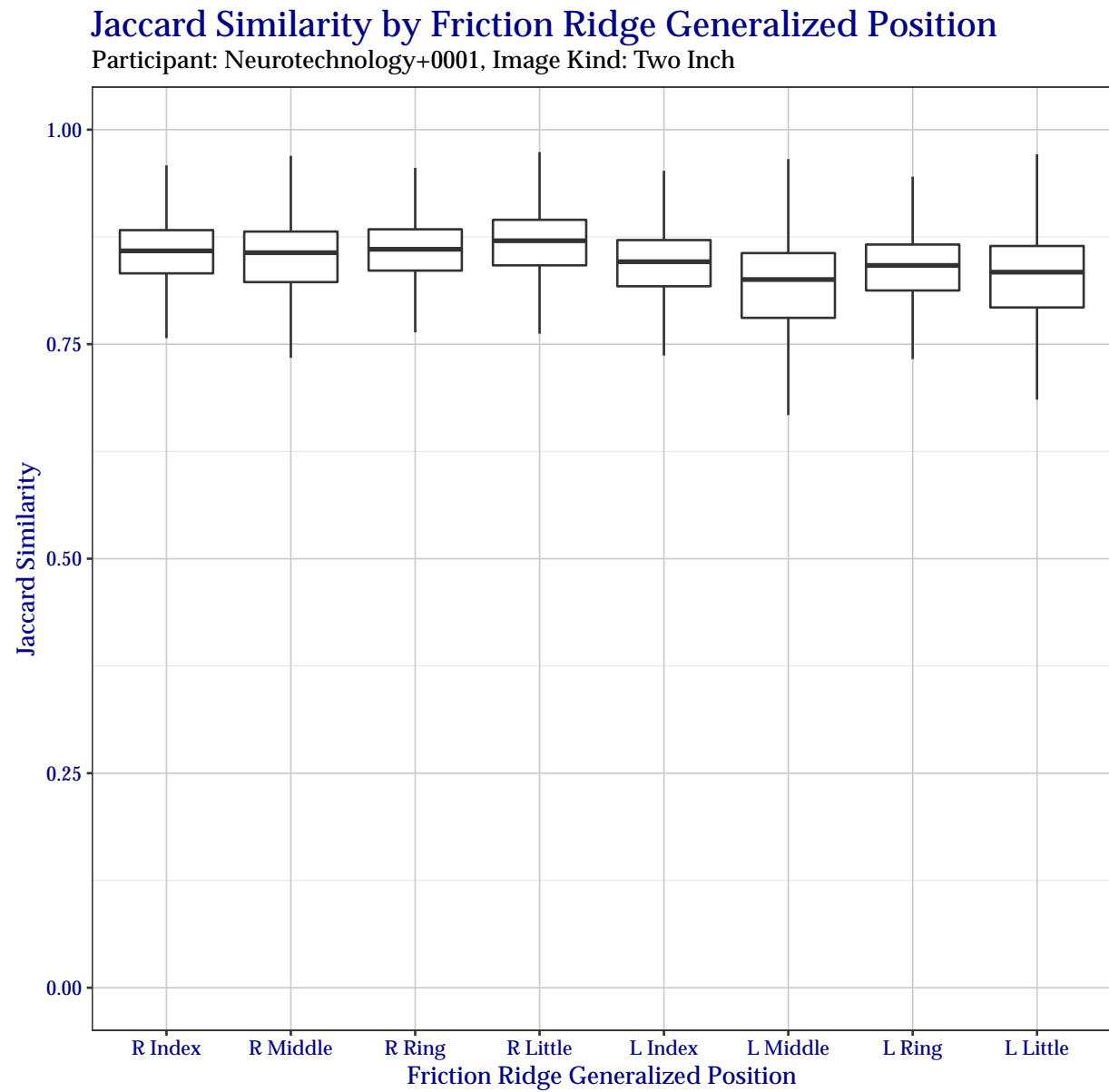
Table 22: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all eight fingers of a TwoInch slap.

Fingers	$\geq 0.5$	$\geq 0.6$	$\geq 0.7$	$\geq 0.8$	$\geq 0.9$	$\geq 0.95$	$\geq 0.98$
<b>Right</b>							
Any	100.0	100.0	100.0	99.4	35.7	1.8	0.0
At Least Two	99.9	99.9	99.9	98.1	14.3	0.1	0.0
At Least Three	99.7	99.6	99.4	92.1	5.2	0.0	0.0
All Four	98.8	98.5	95.0	66.8	1.1	0.0	0.0
<b>Left</b>							
Any	99.9	99.9	99.9	96.0	15.6	0.4	0.1
At Least Two	99.8	99.8	99.6	89.2	3.0	0.0	0.0
At Least Three	99.4	99.3	98.3	74.8	0.4	0.0	0.0
All Four	97.8	96.9	88.8	43.7	0.1	0.0	0.0



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Figure 6: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.



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Figure 7: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 23: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a TwoInch slap.

Fingers	$\geq 0.5$	$\geq 0.6$	$\geq 0.7$	$\geq 0.8$	$\geq 0.9$	$\geq 0.95$	$\geq 0.98$
<b>Right</b>							
Either Index or Middle	99.8	99.8	99.8	97.5	19.8	0.7	0.0
Both Index and Middle	99.1	99.0	96.7	76.3	3.7	0.0	0.0
<b>Left</b>							
Either Index or Middle	99.8	99.8	99.6	91.1	9.2	0.3	0.1
Both Index and Middle	98.5	98.2	93.6	59.5	0.6	0.0	0.0

Table 24: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a TwoInch slap.

Fingers	$\geq 0.5$	$\geq 0.6$	$\geq 0.7$	$\geq 0.8$	$\geq 0.9$	$\geq 0.95$	$\geq 0.98$
<b>Right</b>							
Any	99.9	99.9	99.9	99.0	25.7	1.0	0.0
At Least Two	99.7	99.7	99.6	94.6	8.3	0.0	0.0
All Three	99.0	98.8	96.1	71.8	1.8	0.0	0.0
<b>Left</b>							
Any	99.9	99.9	99.8	94.4	12.2	0.3	0.1
At Least Two	99.5	99.5	99.0	83.3	1.7	0.0	0.0
All Three	98.2	97.8	92.2	54.3	0.1	0.0	0.0